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Can Hemogram Parameters Be Used to Predict the Prognosis in Hospitalized COVID-19 Patients?

Hastaneye Yatan COVID-19 Hastalarında, Hemogram Parametreleri Prognozu Öngörmede Kullanılabilir mi?

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Abstract

Introduction: The Coronavirus disease-2019 (COVID-19) has caused a serious pandemic. Thus, it is important to evaluate patients with data obtained at the first admission. Patients with severe disease should be recognized among patients admitted to the hospital symptomatically. This study aimed to examine the role of admission hemogram parameters in predicting prognosis in patients who were hospitalized for COVID-19.
Materials and Methods: We enrolled all patients diagnosed with confirmed or probable COVID-19 retrospectively. Age, sex, smoking history, chronic disease, hemogram parameters [i.e., leukocytes, neutrophils, monocytes, lymphocytes, hemoglobin, hematocrit, platelets, neutrophil-lymphocyte ratio (NLR), platelet-lymphocyte ratio (PLR), and lymphocyte-monocyte ratio (LMR)], D-dimer, ferritin, albumin, C-reactive protein, and lactate dehydrogenase were recorded. The relationship between hemogram parameters and poor prognosis was evaluated. The need for pulse-steroid therapy, transfer to the intensive care unit, and mortality indicated a poor prognosis.
Results: The median age of the 156 patients enrolled in the study was 63 (24-94) years. Significant correlations were found in the univariate analysis between leukocytes, neutrophils, lymphocytes, monocytes, NLR, PLR, LMR, and poor prognosis (p=0.013, p=0.004, p=0.000, p=0.036, p=0.000, p=0.010, and p=0.025, respectively). In the multivariate analysis, significant correlations were found between leukocytes, NLR, and poor prognosis (p=0.04 and p=0.001, respectively). The cut-off value of the COVID-hemogram score was three points, with 87% sensitivity and 62% specificity. The scoring system determined the risk for a poor prognosis in patients. The median score was 7 (5-8) in those with a poor prognosis and 2 (0-6) in those who did not have a poor prognosis (p<0.001).
Conclusion: Admission hemogram parameters can be used to predict a poor prognosis in patients hospitalized for COVID-19. The use of the COVID-hemogram score in the first admission will guide physicians in making treatment decisions.
Keywords: COVID-19, hemogram, leukocyte, NLR, COVID-hemogram score, prognosis

Öz

Giriş: Koronavirüs hastalığı-2019 (COVID-19) tüm dünyada ciddi bir pandemiye neden oldu. İlk başvuruda elde edilen verilerle hastayı değerlendirebilmek önem taşımaktadır. Semptomatik olarak hastaneye başvuran hastalar arasında, ciddi hastalığın tanınması gerekmektedir. Çalışmamızın amacı; hastaneye yatan COVID-19 hastalarında, tanı anındaki hemogram parametrelerinin prognozu öngörmede kullanılabilirliğini araştırmaktır.
Gereç ve Yöntem: Çalışmaya, kesin COVID-19 tanısı olan ya da COVID-19 hastalığı olasılığı ile hastaneye yatan tüm hastalar retrospektif olarak alındı. Hastalara ait yaş, cinsiyet, sigara öyküsü, kronik hastalık varlığı hemogram parametreleri [beyaz küre, nötrofil, monosit, lenfosit, hemoglobin, trombosit, nötrofil/lenfosit oranı (NLR), trombosit/lenfosit oranı (PLR), lenfosit/monosit oranı (LMR)], D-dimer, ferritin, albümin, C-reaktif protein (CRP) ve laktat dehidrojenaz (LDH) kaydedildi. Hemogram parametreleri ile kötü prognoz (yani pulse-steroid ihtiyacı, yoğun bakım ünitesine nakil ve mortalite kötü prognoz olarak adlandırıldı) arasındaki ilişki değerlendirildi.

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Bulgular: Çalışmaya, alınan 156 hastanın medyan yaşı 63 (24-94) yıl olarak saptandı. Univaryant analizlerde beyaz küre, nötrofil, lenfosit, monosit, NLR, PLR ve LMR ile kötü prognoz arasında anlamlı bir ilişki saptandı (sırasıyla, p=0,013, p=0,004, p=0,000, p=0,036, p=0,000, p=0,010, p=0,025). Multivaryant analizlerde ise beyaz küre, NLR ile kötü prognoz arasında anlamlı bir ilişki saptandı (sırasıyla, p=0,04, p=0,001). Hastalarda kötü prognoz riskini belirleyen COVID-hemogram skorunun kesim değeri, %87 duyarlılık ve %62 özgüllük ile 3 puan olarak saptandı. Skorlama sistemi hastalarda kötü prognoz riskini belirledi. Kötü prognozu olanlarda medyan skor 7 (5-8), kötü prognozu olmayanlarda 2 (0-6) idi (p<0,001).
Sonuç: Hastaneye yatırılan COVID-19 hastalarında, tanı anındaki hemogram parametreleri kötü prognozu öngörmede kullanılabilir. COVID-hemogram skorunun ilk başvuruda kullanılması, tedavi kararı verecek hekimlere yol gösterici olacaktır.
Anahtar Kelimeler: COVID-19, hemogram, lökosit, NLR, COVID-hemogram skoru, prognoz

Introduction

The Coronavirus disease-2019 (COVID-19) has started in China[1] in 2019, spread worldwide rapidly, and caused a serious pandemic[2]. Although most people were asymptomatic or had mild symptoms, the condition of some patients progressed rapidly causing severe acute respiratory failure[3]. With the rapid deterioration and disease progression[4], it is important to be able to evaluate patients with data obtained at the first admission. Patients with severe diseases should be recognized among patients who are admitted to the hospital symptomatically.

Although the relationship between lymphopenia and poor prognosis[5] was identified clearly in the literature, the relationship with other hemogram parameters [i.e., leukocytes, neutrophils, monocytes, hemoglobin, hematocrit, platelets, neutrophil-lymphocyte ratio (NLR), platelet-lymphocyte ratio (PLR), and lymphocyte-monocyte ratio (LMR)] and prognosis are still under investigation. Inflammation caused the development and deterioration of viral infections and inflammation has an important role in course of COVID-19[6]. Thus, the search for biomarkers that indicate inflammation in the blood became important during the COVID-19 pandemic. NLR and PLR indicate inflammation in the blood and are used to predict a poor prognosis[7]. However, their role in predicting prognosis in COVID-19 is still being investigated. Since a hemogram is an easy and inexpensive analysis routinely applied to patients on admission, it may guide physicians in making treatment decisions to prove its place in predicting prognosis.

This study aimed to examine the role of admission hemogram parameters in predicting prognosis in patients hospitalized for COVID-19.

Materials and Methods

Patient Selection

This retrospective, non-interventional, single-center cohort study enrolled all patients diagnosed with confirmed or probable COVID-19. They applied between June 1, 2020, and December 31, 2020. The medical data of these patients were obtained from the Hospital Information Management System. All patients underwent a nasopharyngeal swab test for Severe acute respiratory syndrome-Coronavirus-2 (SARS-CoV-2) using real-time reverse-transcriptase polymerase chain reaction (RT-PCR). A positive result according to the RT-PCR assay of nasal and pharyngeal swab specimens was accepted as a laboratory-confirmed COVID-19. Patients with a history of contact in the last 14 days and symptoms such as cough, fever, and shortness of breath, and patients whose thoracic computed tomography (CT) were compatible with COVID-19 pneumonia were evaluated as probable cases even with a negative RT-PCR result.

Patients who met all of the following inclusion criteria were included in the study:

Inclusion Criteria

1. Patients diagnosed with COVID-19 with a positive PCR test or with typical COVID-19 pneumonia detected in thoracic CT even if the PCR test was negative,
2. Patients whose hemogram values were examined at the time of diagnosis,
3. Patients with adequate clinical data in the Hospital Information Management System.

Age, sex, smoking history, chronic disease, hemogram parameters (i.e., leukocytes, neutrophils, monocytes, lymphocytes, hemoglobin, hematocrit, platelets, NLR, PLR, and LMR), D-dimer, ferritin, albumin, C-reactive protein (CRP), and lactate dehydrogenase (LDH) of the patients were recorded. NLR, PLR, and LMR were calculated using complete blood count results. NLR was calculated by dividing the neutrophil count by the lymphocyte count. PLR was calculated by dividing the platelet count by the lymphocyte count, and LMR was calculated by dividing the lymphocyte count by the monocyte count. Data on the patients' oxygen need on admission, need for steroid/pulse-steroid treatment, length of hospital stay, transfer to the intensive care unit, and mortality were also recorded. Hospitalization was made according to the following criteria specified in the guideline of the Ministry of Health[8]:

1. Aged >50 years,
2. Underlying diseases (cardiovascular disease, diabetes mellitus, hypertension, cancer, chronic lung diseases, and other immunosuppressive cases),

3. Severe pneumonia measures (confusion or tachycardia (>125/min),
4. Respiratory distress or tachypnea (>30/min) or hypotension <90/60 mmHg or SpO_2 <92% or bilateral diffused involvement in lung imaging,
5. Sepsis and septic shock,
6. Cardiomyopathies and arrhythmia,
7. Acute renal damage,
8. Bad prognostic measures in the blood analyses upon admission (blood lymphocyte count <800/µL, serum CRP >40 mg/L, ferritin >500 ng/mL, or D-dimer >1000 ng/mL).

Pulse-steroid therapy was used according to the COVID-19 diagnosis and treatment guidelines of the Ministry of Health[9]. Pulse-steroid therapy was recommended ≥250 mg/day methylprednisolone for three days in patients whose oxygen demand or acute-phase markers increased within 24 h despite 6 mg/day dexamethasone treatment. The relation between hemogram parameters and poor prognosis was evaluated. The need for pulse-steroid therapy, transfer to the intensive care unit, and mortality indicated a poor prognosis.

This study was approved by the Scientific Committee of Dr. Suat Seren Chest Diseases and Surgery Training and Research Hospital (protocol no: 14-13, date: 12.03.2021) and the Ministry of Health COVID-19 Scientific Research Evaluation Committee.

Statistical Analysis

Statistical Package for the Social Sciences (SPSS) Statistics, version 18.0 (SPSS Inc., Chicago, IL, USA), was used for the analysis. The normality of continuous data was tested using the Kolmogorov-Smirnov test. Data were expressed as a median (interquartile range) or number (%), and comparisons were made using the Mann-Whitney U or chi-square test, respectively. Receiver operating characteristics analysis was made to determine the most suitable cut-off value according to Youden's index for poor prognosis, which is an independent variable. The odds ratio was calculated according to the high and low values of hemogram parameters. Cross-squares were created for poor prognosis according to the cut-off value. The distribution was made with the chi-square test method. All comparisons were included in the logistic regression analysis, and in the multivariate analysis, the odds ratio was calculated. A COVID-hemogram score ranging from 0 to 10 points was created to determine the risk of poor prognosis using odds ratios obtained as a result of the univariate analysis. The most appropriate cut-off value was determined in the ROC analysis for scoring, and the median score was calculated in the groups with and without poor prognosis. All comparison tests and type 1 error coefficient were tested in a two-tailed analysis with alpha of 0.05.

Results

The median age of the 156 patients in the study was 63 (24-94) years. Among these patients, 100 (64.1%) were male and 56 (35.9%) were female. Typical COVID-19-specific CT findings were detected in 137 (87.8%) of 145 patients who underwent thoracic CT. The RT-PCR results for SARS-CoV-2 were positive in 123 (78.8%) patients. At least one chronic disease was detected in 93 (59.6%) patients. The most common chronic diseases were hypertension in 56 (35.9%), diabetes mellitus in 40 (25.6%), and coronary artery disease in 21 (13.5%) patients. In total, 108 (69.2%) patients needed oxygen on admission. The demographic characteristics of the study population are presented in Table 1.

Pulse-steroid therapy was administered to 12 (7.7%) of the patients. Sixteen patients (10.3%) needed intensive care during the treatment. Noninvasive mechanical ventilation was applied to five of the patients who were admitted to the intensive care unit, and invasive mechanical ventilation was applied to three of them. Other patients who were admitted to the intensive care unit were followed on oxygen support. During follow-up, 9 (5.8%) patients died of COVID-19 during hospitalization. In the light of all these data, a poor prognosis was observed in 31 (19.9%) patients. The demographic characteristics of those with a poor prognosis are presented in Table 1. In Table 2, laboratory results were presented for both the study population and those with a poor prognosis.

Of the 108 patients who needed oxygen at the time of diagnosis, 80 (74.1%) were male. Moreover, 48 patients did not need oxygen and 20 (41.7%) of them were male. The difference between the groups was significant (p<0.001). Ninety-five patients were smokers. Of the 66 patients who needed oxygen at diagnosis, 42 (63.6%) had a history of smoking. Twenty-nine patients did not need oxygen and 8 (27.6%) of them had a history of smoking. A significant difference was found between the groups (p=0.003). The age was >63 [area under the curve (AUC): 0.693, 95% confidence interval (CI): 0.614-0.764, p<0.0001] in 61 (56.5%) of the 108 patients who needed oxygen at admission and in 13 (27.1%) of the 48 patients who did not need oxygen and the difference was significant (p=0.001).

Of the 31 patients who had a poor prognosis, 25 (80.6%) were male. A total of 125 patients had a poor prognosis, and 75 (60.0%) of them were male. However, the difference was not significant (p=0.053). Among the 95 patients with smoking information, 23 patients had a poor prognosis and 15 (65.2%) had a smoking history. Seventy-two patients did not have poor prognosis, and 35 (48.6%) of them had a smoking history. No significant difference was found between the groups (p=0.251). The age was >64 (AUC: 0.636, 95% CI: 0.555-0.711), p<0.02) in 19 (61.3%) of the 31 patients who had a poor prognosis,

Table 1. Demographic characteristics of the study population and those with poor prognosis

	n, (%)
Study population	
The number of the patients	156
Median age	63 (24-94)
Male/female	100 (64.1)/56 (35.9)
Smoking history (n=95)	50 (52.6)
The intensity of smoking (package/year)	35 (2-100)
Chronic diseases	
Yes	93 (59.6)
No	210 (37.6)
Chronic diseases	
Hypertansion	56 (35.9)
Diabetes mellitus	40 (25.6)
Coronary artery disease	21 (13.5)
Chronic obstructive pulmonary disease	16 (10.3)
Malignancy	13 (8.3)
Asthma	6 (3.8)
Heart failure	2 (1.3)
Patients with poor prognosis	
The number of the patients	31
Median age	65 (25-85)
Male/female	25 (80.6)/6 (19.4)
Smoking history (n=23)	15 (65)
The intensity of smoking (package/year)	40 (8-80)
Chronic diseases	
Yes	17 (54.8)
No	14 (45.2)
Chronic diseases	
Hypertansion	10 (26.3)
Diabetes mellitus	9 (23.7)
Coronary artery disease	6 (15.8)
Chronic obstructive pulmonary disease	5 (13.2)
Malignancy	5 (13.2)
Asthma	1 (2.6)
Heart failure	1 (2.6)

Table 2. Laboratory results of the study population and those with a poor prognosis

	Median (min-max)
Study population	
Hemogram parameters	
Leukocyte	7300/µL (2000-36200)
Lymphocyte	1100/µL (200-10000)
Monocyte	500/µL (0-3800)
Neutrophil	5250/µL (700-30800)
NLR	5.06 (0.45-48)
PLR	239.14 (2.25-1105)
LMR	2.13 (0-7.66)
Hemoglobin	13.4 gr/dL (8.3-18.6)
Hematocrit	39.5 (23.9-56.6)
Thrombocyte	241500/µL (16000-1029000)
Other laboratory findings	
C-reactive protein	61.8 mg/L (0.3-407)
Ferritin	308.8 ng/mL (6.2-2173.6)
D-dimer	972 ng/mL (188-10000)
Lactate dehydrogenase	276 U/L (132-1137)
Patients with poor prognosis	
Hemogram parameters	
Leukocyte	8400/µL (4300-36200)
Lymphocyte	800/µL (300-2300)
Monocyte	400/µL (100-800)
Neutrophil	6900/µL (3700-30800)
NLR	9.7 (1.9-30.8)
PLR	338.6 (66-750)
LMR	1.75 (0.3-7.7)
Hemoglobin	13.4 gr/dL (9.8-16.8)
Hematocrit	39.8 (27.6-50.3)
Thrombocyte	250000/µL (33000-497000)
Other laboratory findings	
C-reactive protein	134.4 mg/L (1.7-407)
Ferritin	376.4 ng/mL (110.1-1947.5)
D-dimer	1761 ng/mL (337-10000)
Lactate dehydrogenase	407 U/L (186-968)

NLR: Neutrophil/lymphocyte ratio, PLR: Thrombocyte/lymphocyte ratio, LMR: Lymphocyte/monocyte ratio, min-max: Minimum-maximum

and 48 (38.4%) of the 125 patients had no poor prognosis. The difference between the groups was significant (p=0.036).

ROC analysis was performed for hemogram parameters according to poor prognosis, and the most appropriate cut-off value was determined (Table 3). Significant correlations were found in the univariate analysis between leukocytes, neutrophils, lymphocytes, monocytes, NLR, PLR, and LMR and poor prognosis (p=0.01, p=0.004, p<0.001, p=0.04, p<0.001, p=0.01, and p=0.03), respectively) (Table 4). In the multivariate analysis performed with hemogram parameters, significant correlations were found between leukocytes, NLR, and poor prognosis (p=0.04 and p=0.001, respectively).

Other laboratory values may be associated with a poor prognosis other than hemogram parameters. The cut-off values that were specific to our study group were identified. Significant correlations were found in the univariate analysis between poor prognosis and CRP >104 mg/L, LDH >333 U/L, albumin ≤3.37, ferritin >836 ng/mL, and D-dimer >1.734 ng/mL (p<0.001,

Table 3. Cut-off values of hemogram parameters determined according to poor prognosis

	Cut-off	AUC (95% CI)	Sensitivity	Specificity	p
Leukocyte	7300/µL	0.641 (0.560-0.716)	71.0	56.0	**0.01***
Lymphocyte	800/µL	0.697 (0.618-0.767)	71.0	72.0	**0.0003***
Monocyte	400/µL	0.590 (0.508-0.667)	61.3	61.6	0.15
Neutrophil	5900/µL	0.701 (0.622-0.771)	64.5	65.6	**0.0001***
NLR	5.27	0.762 (0.687-0.826)	87.1	61.6	**<0.0001***
PLR	327.78	0.622 (0.541-0.699)	48.4	76.8	**<0.03***
LMR	1.75	0.590 (0.508-0.667)	54.8	68.8	0.14
Hemoglobin	13 gr/dL	0.557 (0.475-0.636)	58.1	58.4	0.33
Hematocrit	38.7	0.567 (0.485-0.645)	58.1	58.4	0.26
Thrombocyte	275000/µL	0.560 (0.478-0.639)	77.4	36.0	0.29

*p<0.05 was considered statistically significant.

AUC: Area under the curve, CI: Confidence interval, NLR: Neutrophil/lymphocyte ratio, PLR: Thrombocyte/lymphocyte ratio, LMR: lymphocyte/monocyte ratio

Table 4. Univariate analysis of hemogram parameters according to poor prognosis

	Univariate analysis	
	OR (95% CI)	p
Leukocyte >7300/µL	3.11 (1.3-7.3)	**0.01***
Neutrophil >5900/µL	3.47 (1.5-7.9)	**0.004***
Lymphocyte ≤800/µL	6.29 (2.6-15.0)	**0.000***
Monocyte ≤400/µL	2.54 (1.1-5.7)	**0.04***
NLR >5.27	10.83 (3.6-32.9)	**0.000***
PLR >328	3.10 (1.4-7.0)	**0.01***
LMR ≤1.75	2.68 (1.2-6.0)	**0.03***
Hemoglobin ≤13 gr/dL	1.94 (0.9-4.3)	0.148
Hematocrit ≤38.7	1.94 (0.9-4.3)	0.148
Thrombocyte ≤275000/µL	1.93 (0.8-4.8)	0.228

*p<0.05 was considered statistically significant.

OR: Odds ratio, CI: Confidence interval, NLR: Neutrophil/lymphocyte ratio, PLR: Thrombocyte/lymphocyte ratio, LMR: Lymphocyte/monocyte ratio

p=0.001, p=0.001, p=0.001, and p=0.001, respectively). The presence of chronic disease was not associated with a poor prognosis (p=0.688). The cut-off length of hospital stay in patients with a poor prognosis was 9 days (AUC: 0.722, 95% CI: 0.644-0.790), p<0.001). The length of hospital stay was >9 days in 21 (67.7%) of the 31 patients who had a poor prognosis. However, only 23 (18.4%) of 125 patients without poor prognosis had stayed in the hospital for >9 days. The difference was significant (p<0.001).

Scoring Model

The scoring model consisted of only hemogram parameters that are easy to use clinically. The model was established to create a simple score for poor prognosis in patients with COVID-19. The COVID-hemogram score ranged from 0 to 10 points (Table 5). The cut-off value of the scoring system was 3 points with 87% sensitivity and 62% specificity (AUC: 0.757, 95% CI: 0.68-0.82, p<0.001) (Figure 1). The scoring system determined the risk for poor prognosis in patients. The median score was 7 (5-8) in those with a poor prognosis and 2 (0-6) in those who did not have poor prognosis. The difference was significant (p<0.001).

Discussion

This study showed that the COVID-hemogram score might predict poor prognosis in patients with COVID-19 using only the hemogram parameters on admission. The risk of a poor prognosis increased in patients with COVID-hemogram score >3 points. Significant correlations were detected between poor prognosis and leukocytes and NLR in our study group. Moreover, age >64 years increased the risk of poor prognosis 2.5 times; male sex and smoking did not pose a risk for poor prognosis. Other laboratory parameters, such as CRP, LDH, albumin, ferritin, and D-dimer were associated with a poor prognosis; however, contrary to what is already known, chronic disease was not associated with a poor prognosis.

In a study in Ankara City Hospital conducted in March and April 2020, the clinical and laboratory parameters were investigated in predicting the prognosis of 191 patients with COVID-19[10]. The 46 patients (24.1%) who required intensive care and those who did not were compared. In patients who required intensive care, leukocyte and neutrophil counts, CRP, ferritin, D-dimer, NLR, PLR, and MLR were high; lymphocytes, hemoglobin, and hematocrit levels were significantly lower (p<0.001). Ferritin, NLR, and D-dimer were determined to be indicators of severe disease (p=0.006, p=0.025, and p=0.012, respectively)[10]. In our study, the most important difference was that not only the need for intensive care unit was evaluated; also, poor prognosis, including pulse steroids need and mortality were evaluated. In our study group, the NLR and PLR cut-off values were higher than those in the previous study because they were

Table 5. COVID-hemogram score

	Points
Leukocyte >7300/µL	1
Neutrophil >5900/µL	1
Lymphocyte ≤800/µL	2
Monocyte ≤400/µL	1
NLR >5.27	3
PLR >328	1
LMR ≤1.75	1

NLR: Neutrophil/lymphocyte ratio, PLR: Thrombocyte/lymphocyte ratio, LMR: Lymphocyte/monocyte ratio, COVID: Coronavirus disease

conducted at different times. The study by Bastug et al.[10] was conducted during the initial period of COVID-19. Laboratory parameters might have been affected because the disease course deteriorated[11] and more patients with severe disease were hospitalized.

In a study conducted by Fan et al.[12], the hemogram parameters of 67 patients with COVID-19 with and without intensive care needs were examined. The lymphocyte (p<0.001) and monocyte (p<0.001) counts were low; the neutrophil count (p<0.001) and LDH level (p=0.005) were high. In our study, significant correlations were found between leukocytes, neutrophils, lymphocytes, monocytes, NLR, PLR, LMR, CRP, LDH, albumin, ferritin, and D-dimer and poor prognosis. More significant results might be due to the high number of patients in our study. In the study by Pourbagheri-Sigaroodi et al.[13], which included 19 studies and 2988 patients diagnosed with COVID-19, leukocytosis, neutrophilia, and lymphopenia were observed significantly more often in patients who needed intensive care[13]. A high NLR level and thrombocytopenia were also found to be associated with a poor prognosis[13]. The results of our study group were similar with the results of this study.

Mardani et al.[14] evaluated 200 COVID-19 suspects regarding PCR results and found that 70 (35%) patients were PCR positive and 130 (65%) were PCR negative. Neutrophils (p=0.0001), LDH (p=0.0001), CRP (p=0.04), ALT (p=0.0001), AST (p=0.001), and urea (p=0.001) levels were higher in the RT-PCR-positive group than in the RT-PCR-negative group, and leukocyte count (p=0.0001) and albumin levels (p=0.0001) were lower[14]. In this study, only leukocyte and neutrophil elevations were significant among hemogram parameters; no significant results were obtained in others. Although the purpose of the studies varied, the positive results associated with other hemogram parameters in our study increased the role of hemogram in determining poor prognosis.

Yang et al.[15] investigated the roles of NLR, PLR, and LMR in determining critical disease progression in 93 patients with COVID-19. Critical disease developed in 24 patients. NLR

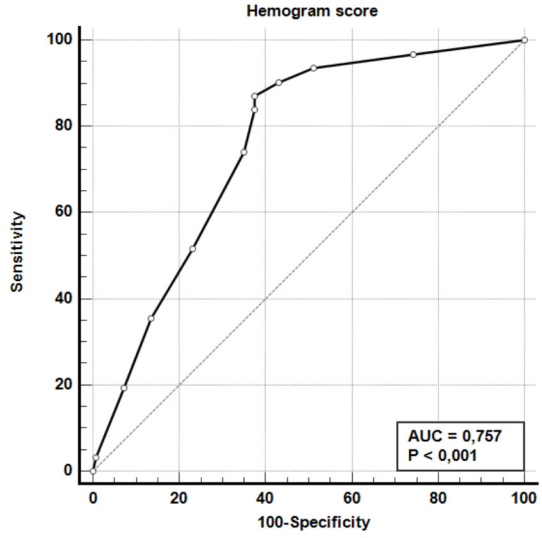

Figure 1. Sensitivity and specificity of the cut-off value of the COVID-hemogram score

COVID: Coronavirus disease, AUC: Area under the curve

(p=0.000), PLR (p=0.000), LMR (p=0.001), and CRP (p=0.003) were found to be associated with critical disease development[15]. The logistic regression analysis was made by excluding factors that might affect the results, such as age and sex. Only NLR was found to be associated with COVID-19 progression (p=0.019)[15]. In our study group, NLR and leukocyte count were found to be associated with a poor prognosis in the multivariate logistic regression.

Liu et al.[16] evaluated mortality in 245 patients with COVID-19. The in-hospital mortality rate was 13.47%. An 8% increase in mortality was detected for each unit increase in NLR (p=0.01)[16]. NLR was stated to be an independent risk factor for in-hospital mortality due to COVID-19, especially in men[16]. The result of this study was similar to those of our study, as NLR was also found to be associated with a poor prognosis.

Despite studies[17-19] in Turkey investigating the predictive value of hemogram parameters, especially NLR in COVID-19, our study had some differences. The most important difference was that the effects of all hemogram parameters on the need for pulse-steroid therapy, need for intensive care, and mortality were evaluated together. All studies were performed in March-April 2020, but our study group included the period after June 2020. Moreover, the inclusion of older people patients in the postvaccination period also contributed to the difference. In addition, the studies were performed in the Emergency Medicine, Internal Medicine, and Infectious Diseases departments. Our study group consisted of patients who were hospitalized in the Chest Diseases department, and pneumonia was detected in 87.8% of the patients. In addition, our study

was conducted with a patient population with pulmonary involvement.

Moreover, our study was the first to define the COVID-hemogram score in determining the poor prognosis. In their study, Liang et al.[20] included 1.590 patients from different centers, and the clinical risk score COVID-GRAM was published to determine critical illness in COVID-19. The COVID-GRAM score was formed from both clinical findings and laboratory values such as chest X-ray abnormalities, age, hemoptysis, dyspnea, unconsciousness, number of comorbidities, cancer history, NLR, LDH, and direct bilirubin. The COVID-GRAM score was more predictive than the CURB-65 score in detecting critical illness ($p<0.001$)[20]. Then, in the study of De Socio et al.[21], the availability of the National Early Warning Score 2 (NEWS2) and COVID-GRAM score was examined in 121 patients with COVID-19 to determine critical illness. The NEWS2 score was created with clinical markers, such as respiratory rate, hypercapnic respiratory failure, oxygen demand, body temperature, systolic blood pressure, pulse rate, and state of consciousness. In this study, both the NEWS2 ($p<0.0001$) and COVID-GRAM score ($p<0.0001$) may be used to identify patients with a critical illness. Also, in the Hanley-McNeil test, the NEWS2 score was superior to the COVID-GRAM score ($Z=2.03$)[21]. In a study by Ucan et al.[22] in our country, CURB-65, PSI, A-DROP, CALL, and COVID-GRAM scores were compared to determine the severity of pneumonia. A-DROP and CURB-65 scores were determined as the best score in indicating mortality in 298 patients with COVID-19. PSI and COVID-GRAM scores detected mortality regardless of age and comorbidity ($p<0.001$)[22]. The COVID-hemogram score was different from other scores because it included only hemogram parameters and could be calculated rapidly in the first evaluation of patients who were admitted to the emergency department.

Study Limitations

This study had some limitations. First, it was a retrospective and single-center study. Although the number of patients was comparable with those of most studies, studies with a larger number of patients may show more significant results. Second, the number of patients who needed intensive care alone, pulse-steroid therapy alone, or mortalities were low, and this prevented the analysis between hemogram parameters and poor prognosis components.

Conclusion

Admission hemogram parameters can be used to predict poor prognosis in patients hospitalized for COVID-19. We created a simple poor prognosis scoring system, which is easy to calculate using hemogram parameters. The use of the COVID-hemogram score on admission will guide physicians in making treatment decisions.

Ethics

Ethics Committee Approval: This study was approved by the Scientific Committee of Dr. Suat Seren Chest Diseases and Surgery Training and Research Hospital (protocol no: 14-13, date: 12.03.2021) and the Ministry of Health COVID-19 Scientific Research Evaluation Committee.

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept - Design - Data Collection or Processing - Analysis or Interpretation - Literature Search - Writing: S.E., G.P., C.K.

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